

DOE Electric Distribution Program Multi-Year RD3 Plan Workshop

**Another Utility's Perspective of Distribution R&DDD
Needs – Creating The Distribution System
For The Next Decade And Beyond**

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August 17, 2004
Oak Brook, IL

Today's Program

- Introduction
- About AEP
- AEP R&D Efforts (Tech Plan)
- Distribution Program
- Distribution/DR Projects
- Discussion/Questions

AEP USA

AEP Facts at a Glance

38,400 MW Generation

65% Coal

26% Natural Gas

7% Nuclear

2% Other

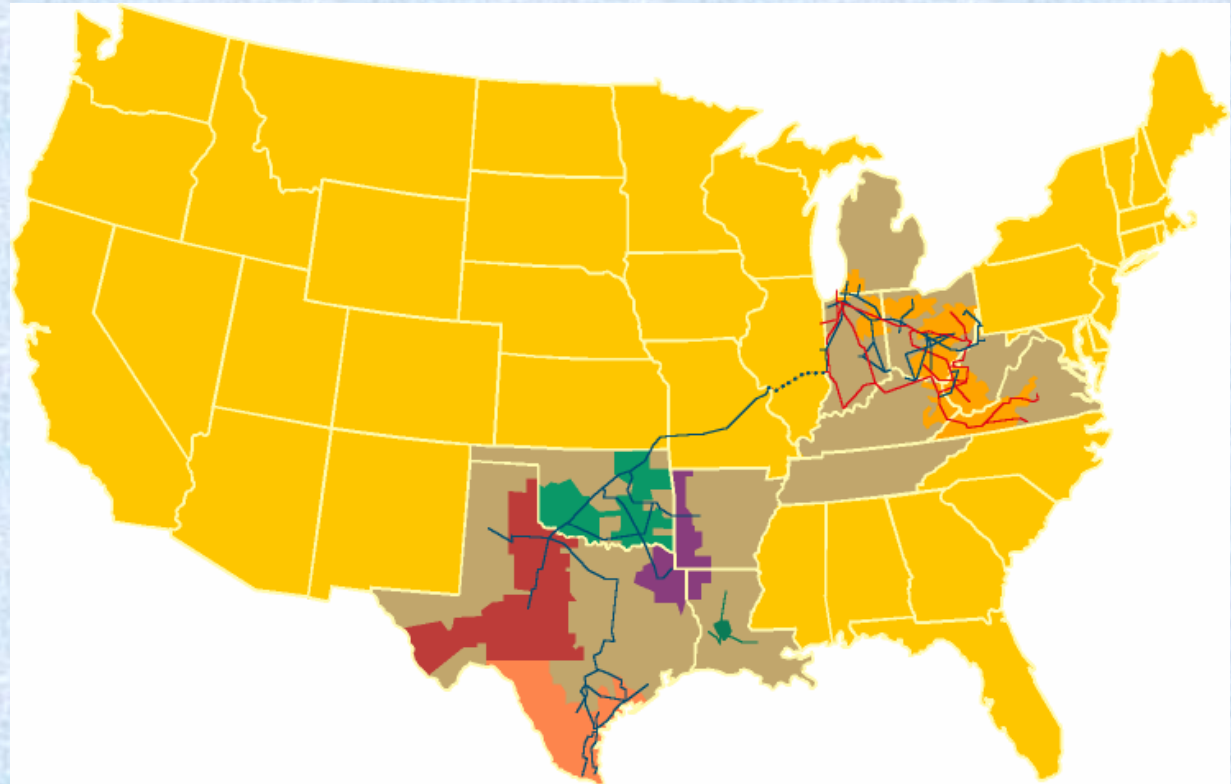
**# 1 Coal Purchaser and
Consumer**

38,000 Miles Transmission

8,000 Miles 230-765 kV

186,000 Miles Distribution

\$55 Billion in Assets



Superior Asset Mix

SIZE, SCALE AND REACH IN ENERGY ASSETS

**America's
Transmission
Backbone**

**38,000 miles
3 NERC regions**

**Top 5 U.S.
Power
Distributor**

**5 million customers
186,000 miles
11 states**

**Top U.S.
Generator**

39000 MW

Fuel

**Largest US coal
consumer (80 mm
tons)**

AEP Strategic Initiatives

- **Distribution Assets**
- **Distributed Resources**
- Environmental Controls
- Renewable Energy
- Advanced Generation
- Transmission Assets
- Emerging Technology
- Nuclear Assets
- Generation Assets

AEP's Corporate Technology Council

- Refines Technology Plan
- Defines major RD&D programs
- Defines relative priorities and allocates resources
- Ensure transparency of technology directions and results
- Utilizes R&D as leverage to drive better strategic investment decisions in our business

Where we are today: The Existing Distribution System

■ Characteristics

- **Largely Radial Feeders**
- **Three Phase Protective Devices**
- **Manual Service Restoration**

■ Limited or Little

- **Real Time Operations Information**
- **Load Transfer Capability**
- **Distributed Generation/Storage**
- **Control and Data Acquisition Capabilities**
- **Communications Between Line Devices and Dispatch Center**
- **Load Control**
- **Service Offerings**
- **Asset Life Extension**

SOME ATTRIBUTES OF THE DISTRIBUTION SYSTEM FOR THE NEXT DECADE

- ***Employee and public safety improved***
- ***Distributed intelligence***
 - ***continuously monitor and control***
 - ***the system reconfigures to minimize power quality events and reduce the length of customer outages***
- ***Single phase tripping and lockout type devices deployed***
- ***Low cost sensors, intelligent devices and communications technology deployed to facilitate distributed decision making***
- ***Distributed generation, storage and power quality conditioning devices deployed to convert feeders and branches to a quasi-networks***
- ***Distributed intelligence deployed to selectively control various customer loads, customer generation, and customer storage devices***

Other Attributes of The Distribution System For The Next Decade

- **Distributed Resources To Automatically Restore Missing Phase Voltages To Three Phase Customer Loads**
- **Distributed Intelligence To Optimize Customer Reliability And Power Quality Using Distribution System And Customer Side Resources**
- **Improved Reliability**
- **Lower costs**

Where We Need To Be In The Future:

The Distribution System For The Next Decade

- **Tools for Improved Safety and Efficiency**
- **Intelligent Automatic Load Transfer Capability**
- **Single Phase Trip/Lock Out Protective Devices**
- **Significant Distributed Generation and Storage Penetration**
- **Expanded System Control and Data Acquisition**
- **Selective Automatic Service Restoration**
- **Communications Between Line Devices and Dispatch Center**
- **Integration of Load Control**
- **Expanded Premium Services Offerings**
- **Expanded Asset Life Extension Capabilities**
- **Ability to Anticipate, Identify and Prevent Potential Causes of Outages**
- **Quasi Networked Radial and Networked Primary Feeders**
- **Automatic Self-healing Distribution System**

The Advanced Distribution Program Cornerstones

- **Develop, demonstrate and deploy distribution technologies that create options for reducing the capital and operating cost**
- **Develop and demonstrate technologies options for new revenue streams from AEP's Distribution assets**

Ultimate Goal : the Self – Healing Grid

■ Achieving the Self-Healing System of the Future

- Improve asset life of the entire energy delivery system
- Reduce the O&M and repair costs of delivery operations
- Create an inherently safer delivery system working environment
- Enable high quality, continuous service to the customer
- Improve the productivity and operating cost of the customer's business operations
- Change the vision of **how the grid is designed, managed and operated**



**Changing the
paradigm of
the grid!**

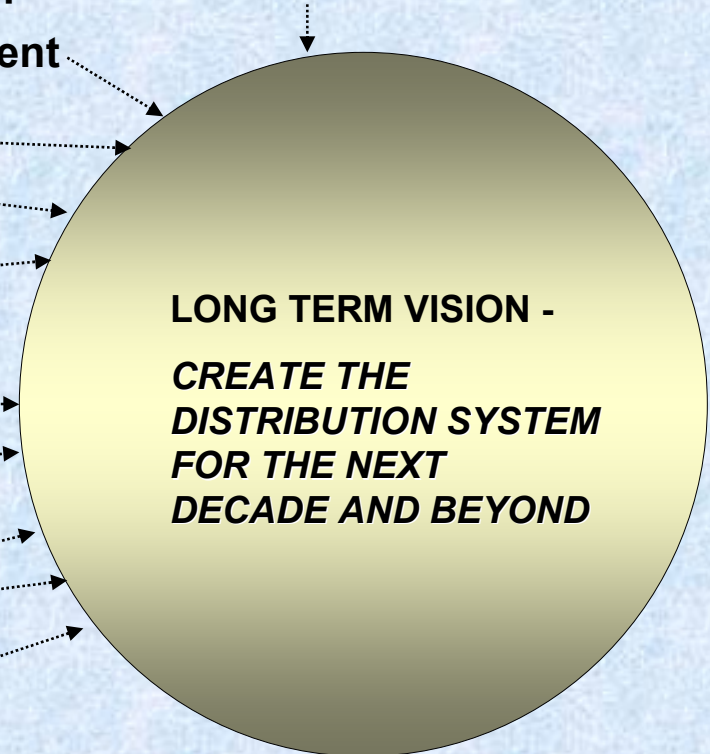
Synergy Between Two Programs

■ Distribution Program

- System Disturbance Monitoring and Equipment Failure Prediction
- Enhanced Distribution System Management
- Asset Life Extension
- Advanced Integrated Communications
- Asset Utilization and Capital Efficiency

■ Distributed Resources Program

- Technology Intelligence
- Testing, Monitoring & Co-Development
- Commercial Demonstration
- Advanced Communications/Control



Creating the Distribution System for the Next Decade

- Develop, Demonstrate and Deploy:
 - Low cost sensors
 - Flexible low cost communications infrastructure
 - Intelligent line devices
 - Distributed generation and storage components
 - Customer load and generation management
 - Distributed intelligence
 - Low cost monitoring systems

Plans for Transforming the Distribution System

The Enabling Technologies

- Advanced Communication methods
- Embedded Processing (Digital techniques)
- **LOW COST**

Low Cost Communications & Control

■ Insights

- Advances in C&C technologies result in more capabilities, lower prices, smaller size
- C & C technologies apply across our lines of business
- Low cost grid connectivity critical for DR, renewables, advanced operating technologies, real time asset management
 - **Central to reducing O&M and capital costs across system**
- Communications is largest impediment to distributed control
- Communication with more nodes opens up security risks
- Enables customer response, dynamic control and on-line diagnostics
- Empowers the customer

BPL - Core Utility Applications

● Customer Interface

Examples:

- Automatic meter reading
- Home gateway (banking, bundled services)
- Service connect/disconnect
- Prepaid metering -via credit card

● Load and Distributed Generation Management

Examples:

- Demand-side management (home automation - A/C, water heater control, etc.)
- Real-time price signaling to customers
- Dynamic loading of station transformers
- Centralized dispatch of distributed generation

● Distribution Automation

Examples:

- Automation of line sectionalizing devices (recloser or switch)
- VAR control (capacitors, regulator settings, voltage measurements)
- Isolation of faults on single phases; rapid restoration by feeding from another intact phase

● Diagnostic Monitoring

Examples:

- Measure conductor temperature and line voltage
- Measure status of line arrestors, fuses, line transformer loading
- Analyze line noise to find local distribution equipment problems (EMI analysis)
- Wood pole deterioration tracking

● Operations Improvement

Examples:

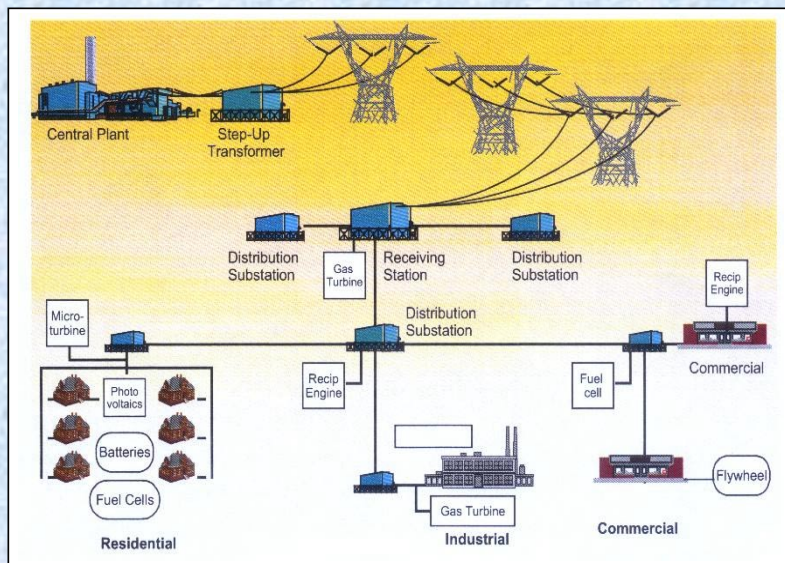
- Lineman access to maps, instruction book online via PLC/radio link
- Create central repository for data fed by PLC reporting (in service operating histories to set maintenance schedules)
- Work management; crew reporting via PLC/radio link

● System Protection

Examples:

- Fault recognition and location
- Replacement for transmission carrier current communications - license concerns and economic benefits
- Adaptive relay setting

Making the “Self-healing Grid” Real



• Our plan

- Leverage communications and control & ongoing industry work
- Develop signature recognition
- Distributed Intelligence

■ Insights

- Achieving the “self-healing” grid is a “bridge too far”
 - Scale of the system impedes rapid modernization
 - System PQ & reliability upgrades hard to justify
- IT, communications and control technology advances make incremental change viable
- Opportunity: “pushing the envelope” on signal differentiation, recognition
- The goal: a fully integrated, automated system that
 - Avoids damage - and repair costs
 - Minimizes capital costs of grid expansion
 - Results in continuous service
 - Is inherently safer

Developmental Activities

- **Advanced Communications /Tools**
- **Advanced Power Electronics Development**
- **Fast Mechanic Switch Development**
- **Advanced Digital Techniques program**
- **Advanced Embedded systems**
- **Advanced Equipment Diagnostics / sensor development**
- **Power Electronics Utility Gateway Integration**
- **Distributed Resource Application (Energy Storage)**
- **Power Line Carrier(Wideband)**

Subprogram : Asset Management

- Enhanced Distribution System Management (System Reliability, Safety & Optimization)
 - VAR Control
 - Smart Switching Line Devices
 - Real-Time Monitoring
 - Remote Switching Line Devices
 - Enhanced Distribution System Monitoring
 - Fixed Capacitor Neutral Shift Detection and Reporting
 - Analyzing Distribution Reliability

Subprogram : System Disturbance Monitoring/Analysis

■ System Disturbance Monitoring and Equipment Failure Prediction

- System Disturbance Monitoring
- Signature Analysis
- Incipient Fault Detection
- Fast Fault Detector
- Circuit Inspection Tool

Subprogram : Life Extension

- Asset Life Extension Management
 - Reliability Centered Maintenance
 - Inspection and Maintenance Tools
 - URD Cable Diagnostic Assessment
 - Estimation of Remaining Life of Cable
 - Underground Vault Ventilation Study
 - Fast Current Limiting Circuit Breakers

Subprogram: Distributed Resources

- Communication & Control - Distributed Assets
- Distributed Resources in Electric Distribution Systems
- Converter-Inverter development
- DR Application Analysis Substation (Energy Storage)
- Other Energy Storage Other Applications
- Fuel Cell Technology Assessments
- Validate,Certify& Characterize DR Devices -TESTING

Sample Distribution R&D Projects

- Li-ion Battery
- Power Line Carrier Development Support
- Energized Cable Detector
- Elbow Pulling Hot Stick
- Wireless Meter Reading in Stations
- Distribution EMI Inspection Tool
- Enhanced Distribution Systems Monitoring
- Fast Fault Detector
- Disturbance Signature Analysis
- System Disturbance Monitoring
- Communications for Reclosers/Switches, etc
- VAR Control Project Phase II - Voltage Regulators & Reclosers
- Faulted Circuit Indicator
- Flicker Monitor

Optimization Projects

- **Incipient Fault Detector**
- **Distribution VAR Control**
- **Fast Fault Detector**
- **Premium Power Park Project**
- **Signature Analysis (PQ)**
- **System Disturbance Monitoring**
- **Enhanced Distribution Systems Monitoring**

Some Experience to Date:

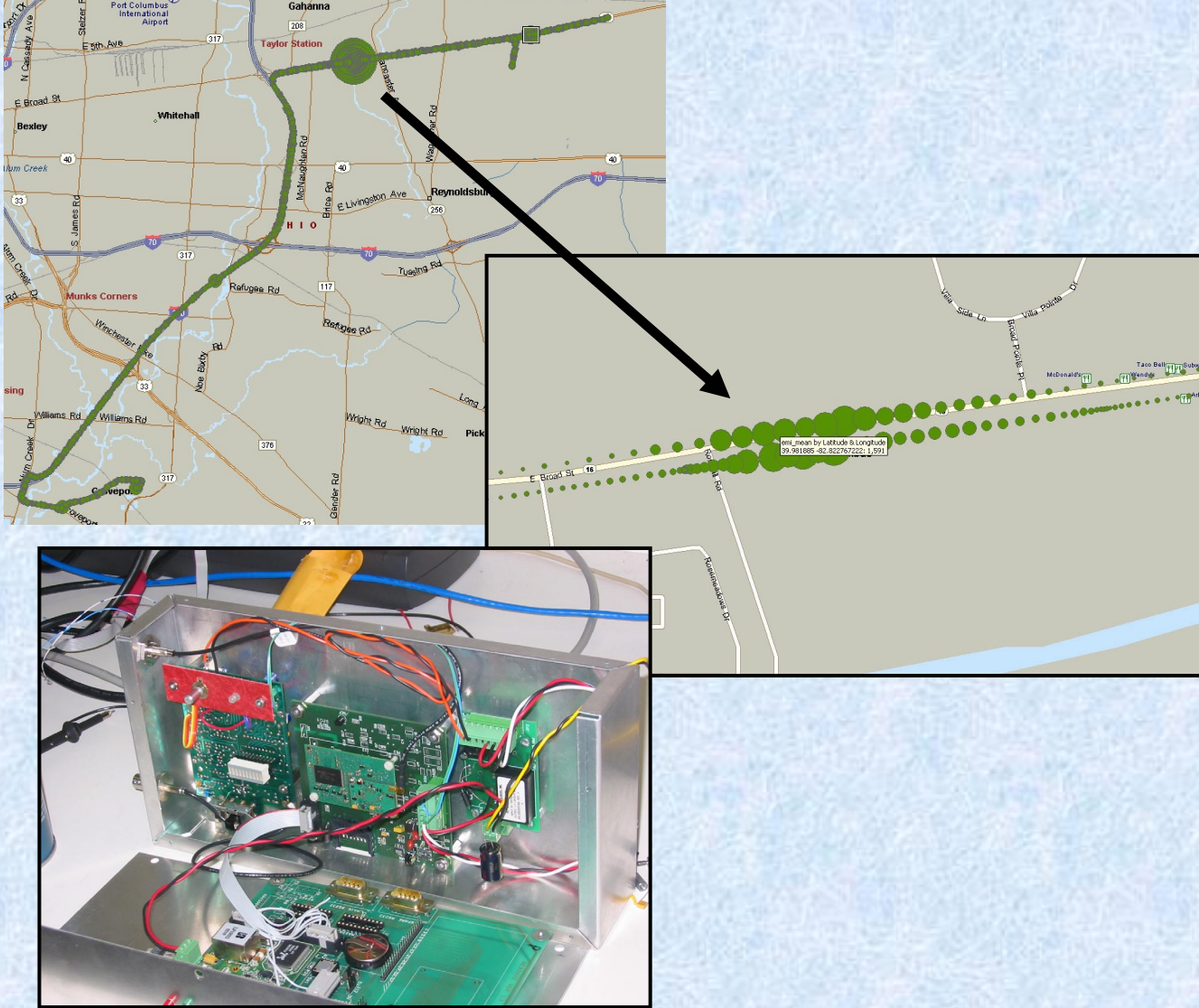
- Incipient Fault Detector
- Distribution VAR Control
- Fast Fault Detector
- Li-Ion Battery
- Solid State Transfer Switch
- Premium Power Park Project
- Power Line Carrier
- System Disturbance Monitoring
- Sodium Sulfur Battery
- Distribution Static Compensator

Early Successes

- VAR Control project
- Incipient Fault DSP Platform
- Fast Fault Detector
- GSU Health monitor
- Digital Fault Recorder
- PQ Monitor
- EMI Drive-by Tool

An early Success : VAR Control Project

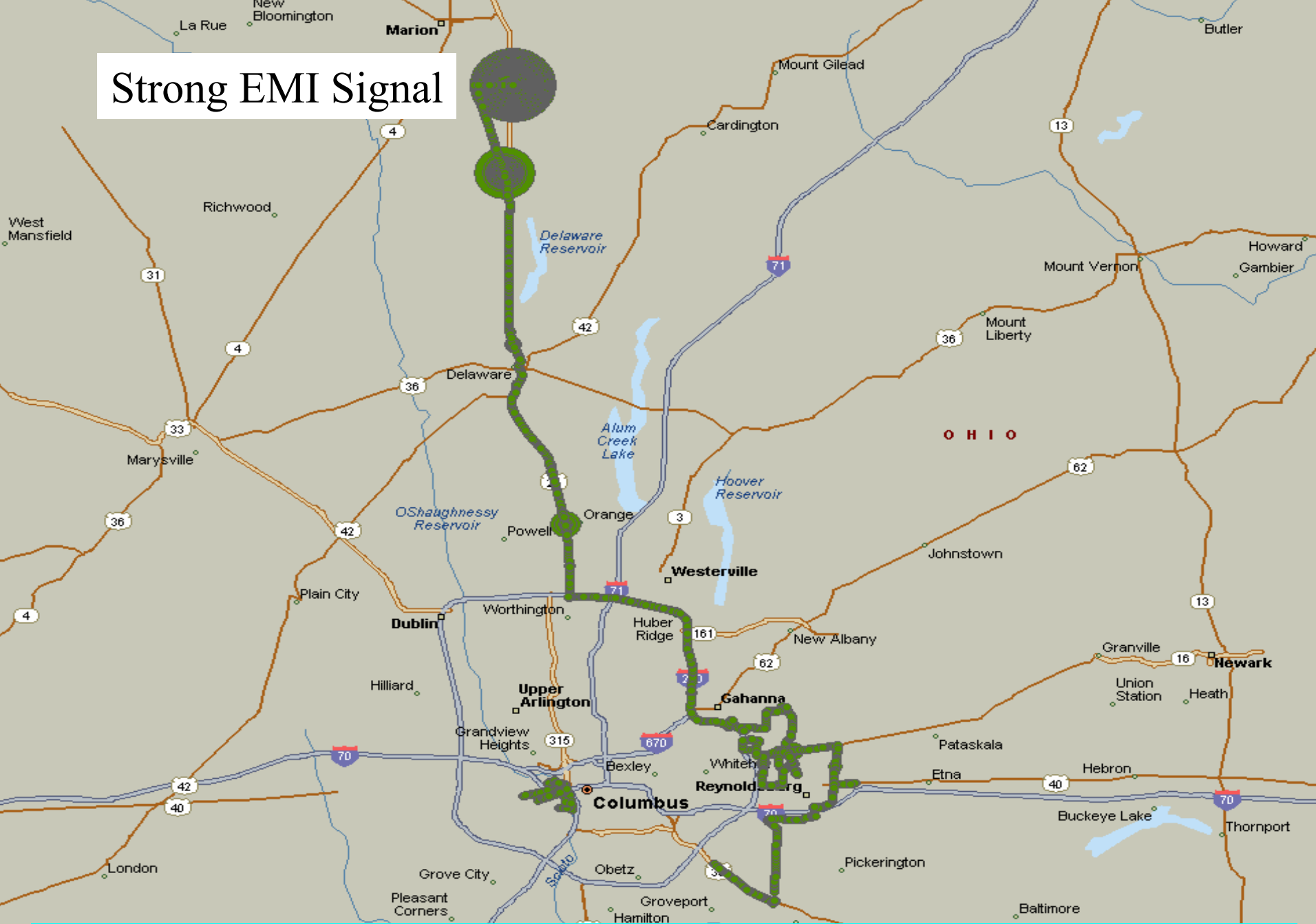
- Develop the technology necessary to automate Capacitor Controls on the distribution system
 - Using various communications platforms
 - Communicate with control through the internet
 - Successfully demonstrated at Dolan (summer '02)
 - Advantages
 - Cost ~ 1/3 the cost of a conventional off-the-shelf control
 - Internet feature allows for multiple simultaneous access to many controls
 - Keeps AEP infrastructure cost low



Distribution EMI Line Survey – Meter Reading Route

- Time, Location, EMI, and Audio
- Data transfer using 64 MB MultiMediaCard
- 350+ hours record time on MMC (>1 month)

Strong EMI Signal



Distribution Drive-By in Central Ohio - Overview

The Program Focus

- **Direct technology resources to sensors, controls, diagnostics, distributed generation and storage and communications**
- **Asset utilization and life extension: Highest value and significant impact to Distribution foot print.**
- **Engage with AEP Partners to develop and retain IP and intellectual capital that can be leveraged beyond AEP service territory and regulated activities**
- **Collaborate with industry partners to leverage resources and see significant value**

The Transition to Tomorrows Distribution System

The Transition STARTS NOW !!

■ Characteristics

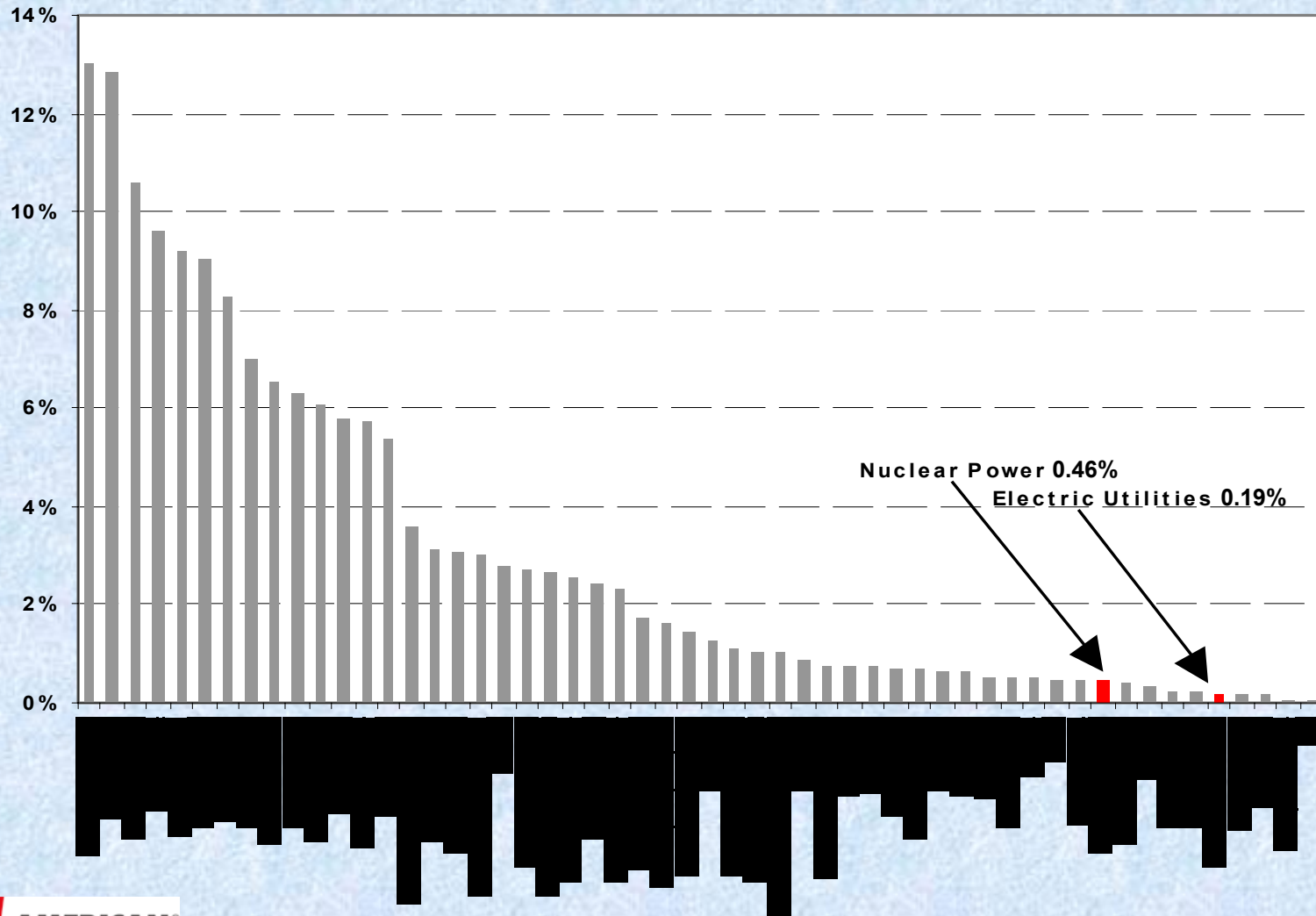
- **Smarter, Flexible**
- **More Reliable**
- **Improved Power Quality**
- **Automated, Self-Healing Features**

■ Enabling Technologies

- **Digital Techniques**
- **Advanced Communications / Sensors**
- **Power Electronics**
- **Lower Costs**

Electric Utility vs. Industry R&D Spending

Chart 1. R&D share of revenue by industry, 1997-1998. Source: National Science Foundation.



Corporate Technology Development

“It is not too difficult to estimate what pioneering and its attendant perils have cost us. But what would have been lost to us by not pioneering can never be evaluated.”

Philip Sporn

President 1947-1961

AMERICAN ELECTRIC POWER COMPANY

AEPs Advanced Distribution Initiative - Transformation

■ Objectives

- **Lower Costs**
- **Life extension**
- **Enhanced security**
- **Better asset Utilization**

■ Method of Implementation

- **Multi-step**
- **Accelerate Technology Acceptance**

■ Critical Technologies

- **Electric Storage**
- **Distributed Smart Sensors**
- **Power electronics**
- **Advanced Communications**
- **Embedded Systems**

Comments, Questions, Discussion

■ ??????????

■ How we get there ?

LONG TERM VISION -

***CREATE THE
DISTRIBUTION SYSTEM
FOR THE NEXT
DECADE AND BEYOND***